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HIGHLY CORROSION- AND WEAR-RESISTANT Fe-BASED SINTERED ALLOY
[Taishokusei Oyobi Taimamosei No Sugureta Fe-Ki Shoketsu Gokin]

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SPECIFICATION

1. Title of the Invention

Highly Corrosion- and Wear-Resistant

Fe-Based Sintered Alloy

2. Claim

Highly corrosion- and wear-resistant Fe-based sintered alloy that characteristically has a composition (weight%) comprising

Cr	:	16-26%,
Ni	:	8-16%,
Mn	:	1-5%,
P	:	0.05-1.2%,
B	:	0.02-1.2%, and
C	:	0.05-0.5%,

wherein the remainder is Fe and unavoidable impurity.

3. Detailed Description of the Invention

Field of Industrial Utilization

This invention relates to an Fe-based sintered alloy that exhibits an excellent corrosion resistance and an excellent wear resistance.

Prior Art

Various sintered stainless steels have been used to produce components that have a complex shape (e.g., compressor nozzles for automotive air conditioners, mounting components for industrial cameras) and that must exhibit an excellent corrosion resistance and wear resistance. Sintered stainless steel offers a cost advantage over production by machining from bulk cast stainless steel, which has a mediocre machinability.

Problem to Be Solved by the Invention

However, while this conventional sintered stainless steel has a relatively good corrosion resistance, it is substantially unable to provide a high hardness, i.e., a

Vickers hardness of at least 200, which is caused by the fact that, like sintered components in general, it has a lower density than the bulk cast material. As a result, sintered stainless steel has had a relatively short service life in those applications for it that require wear resistance in combination with corrosion resistance.

On the other hand, efforts have been made to raise the carbon content of the above-described conventional sintered stainless steel in order to raise its hardness; however, this causes a deterioration in the corrosion resistance,

/2

which makes it impossible to provide properties that thoroughly satisfy the requirements cited above.

Means Solving the Problem

The present inventors therefore carried out investigations from the perspective described above in order to develop a material that would be provided with corrosion resistance and wear resistance. As a result, they acquired the knowledge that an Fe-based sintered alloy that has a composition, expressed in weight% (below, % denotes weight%), comprising

Cr : 16-26%,

Ni : 8-16%,

Mn : 1-5%,

P : 0.05-1.2%,

B : 0.02-1.2%, and

C : 0.05-0.5%,

wherein the remainder is Fe and unavoidable impurity, has a high density and also a high hardness and becomes even harder when an ageing treatment is carried out and accordingly is equipped with both an excellent wear resistance and an excellent corrosion resistance.

The present invention was achieved based on this knowledge. The reasons for the above-cited limitations on the component composition are described in the following.

(a) Cr

The Cr component enters into solid solution in the matrix and thereby raises the corrosion resistance of the alloy; it also bonds with components such as the Mn and P to form a hard precipitate, thus raising the hardness of the alloy. However, a desirable development of these activities is not obtained when the content is less than 16%. On the other hand, a content in excess of 26% results

in a reduction in the toughness of the alloy. The Cr content is thus set at 16 to 26%.

(b) Ni

The Ni component enters into solid solution in the matrix and thereby stabilizes the austenitic phase in the matrix; it additionally facilitates the entry into solid solution by solute components during solution heat treatment, thus improving the age hardening capacity; and it acts to improve the corrosion resistance. However, a desirable development of these activities is not obtained when the content is less than 8%. On the other hand, at a content in excess of 16%, not only is there no additional increase in the activities cited above, but the workability, for example, the machinability, is impaired. The Ni content is thus set at 8 to 16%.

(c) Mn

The Mn component, through its co-presence with the Ni, acts to stabilize the austenite, improve the age hardening capacity, and improve the corrosion resistance; in addition, it also acts to improve the wear resistance by promoting work hardening due to working strain. However, a desirable development of these activities is not obtained when the Mn

content is less than 1%. On the other hand, at a content in excess of 5%, the Mn component, being an easily oxidizable component, undergoes oxidation during sintering, leading to an increase in the oxygen content in the alloy and a decline in toughness. The Mn content is thus set at 1 to 5%.

(d) P and B

These components jointly form a eutectic with Fe; in addition, the alloy undergoes a fine densification — and thus an increase in density — due to a synergetic effect only when both of these components are present. Moreover, during ageing they form hard precipitates with, for example, the Cr and Fe, and thus act to improve the wear resistance. However, when the P content is less than 0.05% or when the B content is less than 0.02%, a desirable development of these activities is not obtained. On the other hand, when either content exceeds 1.2%, the quantity of hard precipitate becomes excessively large, causing a loss of toughness. The content is therefore set at 0.05 to 1.2% for P and 0.02 to 1.2% for B.

(e) C

The C component inhibits oxidation by Mn, which is an easily oxidized alloy component, and in addition forms

carbides, which increase the hardness and improve the wear resistance. When its content is less than 0.05%, a desirable development of these activities is not obtained. On the other hand, when its content exceeds 0.5%, in particular the amount of Cr carbide formed undergoes an increase, which causes a decline in the amount of Cr in solid solution in the matrix and hence a decline in the corrosion resistance of the alloy. The C content is therefore set to 0.05 to 0.5%.

The alloy of the present invention can be produced as follows. The following can be used as the precursor powder: the elemental powder for each component; alloy powders in which an easily oxidizable component, such as Cr, Mn, and P, is alloyed with, for example, Fe;

/3

and an alloy powder that has the prescribed final composition. The precursor powders are blended into the prescribed composition and are mixed under the usual conditions, after which press molding into a compact is carried out. Sintering is then performed in a low-dew point reducing atmosphere or in a vacuum in order to prevent oxidation. As necessary, sintering is followed by a solution heat treatment of heating to approximately 1050 to 1150° in a nonoxidizing atmosphere and then quenching. An

ageing treatment at approximately 550 to 750°C is subsequently carried out in order to achieve the prescribed hardness.

Examples

The Fe-based sintered alloy of the present invention is more specifically described below using examples.

The following precursor powders were prepared: -100 mesh elemental Fe powder; -100 mesh atomized Fe alloy powder having a composition of Fe, 18% Cr, 10% Ni, 3% Mn, and 0.1% C; -200 mesh Ni carbonyl powder; -100 mesh atomized Fe alloy powder having a composition of Fe, 27% Cr, and 0.3% C; -100 mesh atomized Fe-Mn alloy powder (Mn content: 75%); -100 mesh atomized Fe-P alloy powder (P content: 23%); -100 mesh atomized Fe-B alloy powder (B content: 20%); -100 mesh ground Cr powder; and -200 mesh graphite powder. These precursor powders were blended to give the prescribed composition; zinc stearate (lubricant) was admixed thereinto at the rate of 1% with reference to the blended powder; a compact was press molded from the resulting powder mixture at 5.5 ton/cm^2; and this compact was then heated in a 1-atmosphere decomposed ammonia atmosphere at 550°C to remove the lubricant and was

thereafter sintered by holding for a prescribed time in the range of 1 to 2 hours in a 0.05 to 0.15 torr vacuum at a prescribed temperature in the 1140 to 1250°C range. Holding for 30 minutes at 1130°C during cooling after sintering was then carried out, after which a cooling solution heat treatment was executed. Execution of an ageing treatment by holding in a 1-atmosphere nitrogen atmosphere at a prescribed temperature in the range of 570 to 710°C for a prescribed period of time in the range of 1.5 to 5 hours then produced Fe-based sintered alloys 1 to 10 of the present invention having the component compositions given in Table 1 and conventional sintered stainless steels 1 and 2 having the component compositions given in Table 1.

The resulting Fe-based sintered alloys 1 to 10 of the present invention and conventional sintered stainless steels 1 and 2 were then subjected to measurement of their relative density, Vickers hardness (load: 5 kg), tensile strength, and elongation. They were also submitted to salt-spray testing, with inspection of rust development after 24 hours. The results are reported in Table 1.

Effects of the Invention

As is clear from the results reported in Table 1, the Fe-based sintered alloys 1 to 10 according to the present invention exhibited an excellent corrosion resistance in all instances; they also exhibited a high density, a high hardness, and a high strength, and because of this exhibited an excellent wear resistance in all instances. In contrast to this, the conventional sintered stainless steel 1, while having an excellent corrosion resistance, exhibited a poor wear resistance. In addition, conventional stainless steel 2, in which the C content was increased in order to raise the wear resistance, had a low corrosion resistance although it did have an excellent wear resistance.

As described hereinabove, the Fe-based sintered alloy of this invention exhibits an excellent corrosion resistance and wear resistance,

/4

and for this reason can of course be used in those fields where these properties are required. It is also non-magnetic and thus also stably exhibits excellent properties long term when used in fields where magnetism is not required.

Table 1.

type of alloy		component composition (weight%)							relative density (%)	hardness (Hv)	tensile strength (kg/mm^2)	elon-gation (%)	rusting
		Cr	Ni	Mn	P	B	C	Fe + impuri-ties					
Fe-based sintered alloys of the invention	1	16.1	11.2	3.0	0.12	0.19	0.32	remainder	95	230	65	25	absent
	2	16.8	15.3	1.1	0.11	1.13	0.30	remainder	97	250	60	10	absent
	3	17.0	13.1	4.0	1.02	0.31	0.058	remainder	98	270	60	15	absent
	4	18.3	10.4	3.2	0.81	0.40	0.41	remainder	96	280	75	20	absent
	5	20.2	12.2	3.0	0.60	0.92	0.32	remainder	97	270	70	25	absent
	6	19.8	11.9	2.1	0.68	0.21	0.22	remainder	96	260	65	15	absent
	7	20.0	12.2	2.0	0.72	0.20	0.21	remainder	97	280	70	20	absent
	8	22.3	9.4	1.7	1.13	0.23	0.33	remainder	99	310	75	10	absent
	9	24.1	8.1	1.0	0.20	0.21	0.11	remainder	96	290	70	25	absent
	10	25.7	8.0	1.1	0.70	0.12	0.48	remainder	97	300	60	10	absent
conven-tional sintered stainless steels	1	18.5	8.3	–	0.52	–	–	remainder	87	110	35	20	absent
	2	17.3	–	–	–	0.2	0.65	remainder	89	430	20	2	dark red rust over entire surface